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El Niño Climate event in the bioeconomy sustainability of *Engraulis ringens* in Peru

Evento climático El Niño en la sostenibilidad bioeconómica de *Engraulis ringens* en Perú

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Abstract

Fishery resource *Engraulis ringens* "anchovy" bioeconomy sustainability is being affected by El Niño climate event whose intensities ranges from very strong, weak and moderate along the Peruvian coast. Paita, Chimbote, Huacho, Callao, Pisco and Ilo fishing ports were hit by "El Niño" from weak to moderate intensities in the years 2002-2003, 2006; 2008-2009. This caused Chimbote to deliver a production volume of 334.320 tons which represents the biggest bioeconomy sustainability in 44% with a value of 232.770 x 10^6 million USD.

Keywords: El Niño; bioeconomy sustainability; *Engraulis ringens;* anchovy.

Resumen

La sostenibilidad bioeconómica del recurso pesquero *Engraulis ringens* "anchoveta" es afectada por el evento climático El Niño de intensidades muy fuertes, débiles y moderadas en el litoral costero del Perú. Los puertos pesqueros de Paita, Chimbote, Huacho, Callao, Pisco e Ilo presentaron intensidades del Evento Climático El Niño de intensidad moderada y débil en el 2002-2003, 2006; 2008-2009, presentando Chimbote un volumen de producción de 334,320 t lo que representa la mayor sostenibilidad bioeconómica con 44% y un valor U.S.D 232,770 x 10^6 millones.

Palabras Clave: El Niño; sostenibilidad bioeconómica; *Engraulis ringens*; anchoveta.

1. Introduction

Bioeconomy sustainability is defined as the economic benefit provided to our society by fishery resources without affecting future generations. However, *Engraulis ringens* fishery overexploitation caused by inadequate government policies is threatening *E. ringens* fishery from being biobased sustainable in the future. According to Mullon *et al.* (2005), between 1950 and 2000 overfishing caused unsustainability in approximately a quarter in the extractions volumes around the world. In addition, on the north coast of Peru, the bioeconomy sustainability of anchovy is being affected by El Niño climate event equatorial countercurrent. This event comes with an increase in the thermal anomalies in the Sea Surface Temperature SST in approximately + 3 °C generally during summertime reaching top intensities tracked in the following years: 1925-1926; 1972-1973; 1982-1983 and 1997-1998 (Capel, 1999).

In Peru, bioeconomy sustainability of anchovy reached its peak between the 60's and 70's with a range in unloading volumes between 3.5 x 10^6 and 12.3 x 10^6 tons (INEI, 2004), the largest unloading took place in Chimbote and Callao. According to INEI (2004) and FAO (2003) it was reported that in 1998 anchovy extraction decreased in 1.2 x 10^6 tons due to EL Niño 97-98 events. However, fishmeal and fish oil exports fluctuated between 588 and 1.519 per ton and the fishing GDP contributed 0.4% of the national GDP with 116.413 x 10^6 million PEN. According to CAF (2000), El Niño 1997-98 event generated losses in infrastructure which fluctuated between 14.93 x10^6 and 6.88 x10^6 million USD, as a result fishing pelagic species such as anchovy depleted. The anchovy fishery industry is a strategic element for the country's economy, as it is the second largest source of exports after mining, as in 2001 this represented 1.2 x 10^6 million USD in exports. Peruvian anchovy allows the growing and

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development of the fishing industry around the world.

Regarding fisheries regulations, the Ministry of Production established individual quotas for the maximum allowable catch limit per fishing season and per fishing vessel for 2009, with Legislative Decree 1084, General Fisheries Law 25977 (Diario El Peruano, 2009).

Regardless all stablished fishery regulations international anchovy trade will be affected by El Niño weather events. According to a study carried out by Tania Flores from the National University of Trujillo in 2015, concluded that in the future there will be no bioeconomy sustainability of anchovy based on observations between January 2000 and June 2011 where the average unloading figures were of 3.20 Million tons and its statistical projection presented a negative trend up to 2050 in six fishing ports: Paita, Chimbote, Huacho, Callao, Pisco and Ilo.

The study states that due to the frequency and intensity of El Niño event; fishmeal and fish oil production will not reach the average sustainable production in Paita's fishing ports. However, Chimbote port that will maintain sustainable production regardless of the El Niño climate event.

Therefore, the goal was to determine the influence of El Niño climate event on the bioeconomy sustainability of *Engraulis ringens*.

2. Materials and methods

The research was conducted using as sample six fishing ports in Peru: Paita 05º 04' 55.9''S; 81º 07' 39.0''W, Chimbote 09º 04' 32.2''S; 78º 35' 52.8''W; Huacho 11º 07' 32.2''S; 77º 37' 40.8''W; Callao 12º 04' 01.2''S; 77º 04' 26.4''W; and Pisco 13º 42' 32.8''S; 76º 13' 21.4''W and Ilo 17º 14' 16.8''S; 71º 07' 51.6''W. Sea Surface Temperature - SST data was obtained from the Peruvian Sea Institute - IMARPE between 2000 and 2011. The Pattern of Sea Surface Temperature - PSST in degrees Celsius was determined based on monthly and annual averages obtained during the investigation period. Later thermal anomalies were determined considering PSST zero value. Based on the difference between annual average temperature and PSST thermal anomalies were obtained in colors: positive in red /negative in blue. The intensity and magnitude of El Niño Climate event was categorized with the Local Atmospheric Energy Index - IEAL (Alva, 2008) in weak (0 <0.5), moderate (0.5 <1.0), strong (1.0 <1.5) and very strong (1.5 <2.0). Likewise, data was obtained on the production in tons registered by the Ministry of Production from 2000 to 2011. In addition, volume production average during the investigation period was obtained and the criterion for determining bioeconomy sustainability was to consider Historical Production Volume – HPV as a pattern and value of zero, considering a positive tendency when overcoming HPV as sustainable bioeconomy and with a negative tendency when HPV are not reached.

Surveys were conducted to the heads of production area in eight fishing companies to learn about social, economic and environmental aspects; the companies were: Tecnológica de Alimentos S.A., Langostinera Caleta Dorada S.A.C., owned by Pesquera Diamante S.A., Cía. Pesquera del Pacífico Centro S.A., Pesquera Exalmar S.A.A., Corporación Pesquera Inca S.A.C., CFG Investment S.A.C., Pesquera Hayduk S.A. and Austral Group S.A.A.

3. Results and discussion

Fishing ports of Paita, Chimbote, Huacho, Callao, Pisco and Ilo evidenced annual average thermal anomalies of El Niño weather events between weak and moderate intensities in the years 2002-2003, 2006; and 2008-2009, because The Pattern of Sea Surface Temperature - PSST were 19.0; 19.6; 16.5; 15.8; 20.2 and 15.5 °C respectively (Figure 1).

Quispe y Vásquez (2015) reports that the El Niño Event had a thermal anomaly of + 0.6 °C from July to October 2002, in 2003 the phenomenon extended up until March with weak and moderate events due to the presence of winds that gradually decreased along the eastern and central Pacific.

In 2006 and 2007, El Niño was of weak intensity with duration of three months between December and March reaching thermal anomalies higher than +1 °C. These thermal anomalies affected the bioeconomy sustainability of the anchovy, because of its negative trend in production volumes accord with Galarza *et al*. (2015) that state that since 2005 production of fishmeal and fish oil have been decreasing gradually.

However, fishing ports of Chimbote, Callao; and Pisco reached their highest average production volumes of fishmeal and fish oil in: 334.320, 101.960 and 143.090 tons respectively (Figure 2) (B, D and E) this meant for Chimbote port to reach the highest bioeconomy sustainability with 44% of the production volumes, obtaining an average income of 232.770 x 10^6. Million USD, this is consistent with Zafra (2005) who classified Chimbote as the most important port in the Country to stand out with the highest landing volumes in industrial anchovy fishing.

Paita, Huacho and Ilo fishing ports reached the lowest average production volumes of fishmeal and fish oil with 61.930, 36.850; and 85.840 tons respectively (Figure 2) (A, C and F). Figures evidenced that Huacho was the port with the lowest bioeconomy sustainability reaching 5% in production volumes with an average income of 25.220 x 10^6 million USD. The bioeconomic unsustainability caused by the El Niño event during the study has caused a sharp increase in the price of the international fishmeal and fish oil market. Inferred Talledo (2010), Galarza *et al.* (2015) that exports of fishmeal and fish oil for Indirect Human Consumption - IHC have contributed to the country's economy.

Galarza *et al.* (2015) also mentioned that from 2005 and onwards there was a sustainable price trend and a decreasing growth in fishmeal and fish oil production, same conclusions obtained in this research. In 2002 and 2003 there were economic losses ranging from -18.5 to -37%, while in 2008 and 2009 profits were of 31.9 and 37.2%. In addition, Yonashiro and Balbín (2016) pointed out that in 2002, 2006 and 2008 monetary value of fishmeal was 542; 1.335; 1.797 USD per ton, for fish oil; 431; 657; 1.493 USD per ton. The exports incomes were of 892; 1.335 and 1.797 x 10^6 million USD respectively.

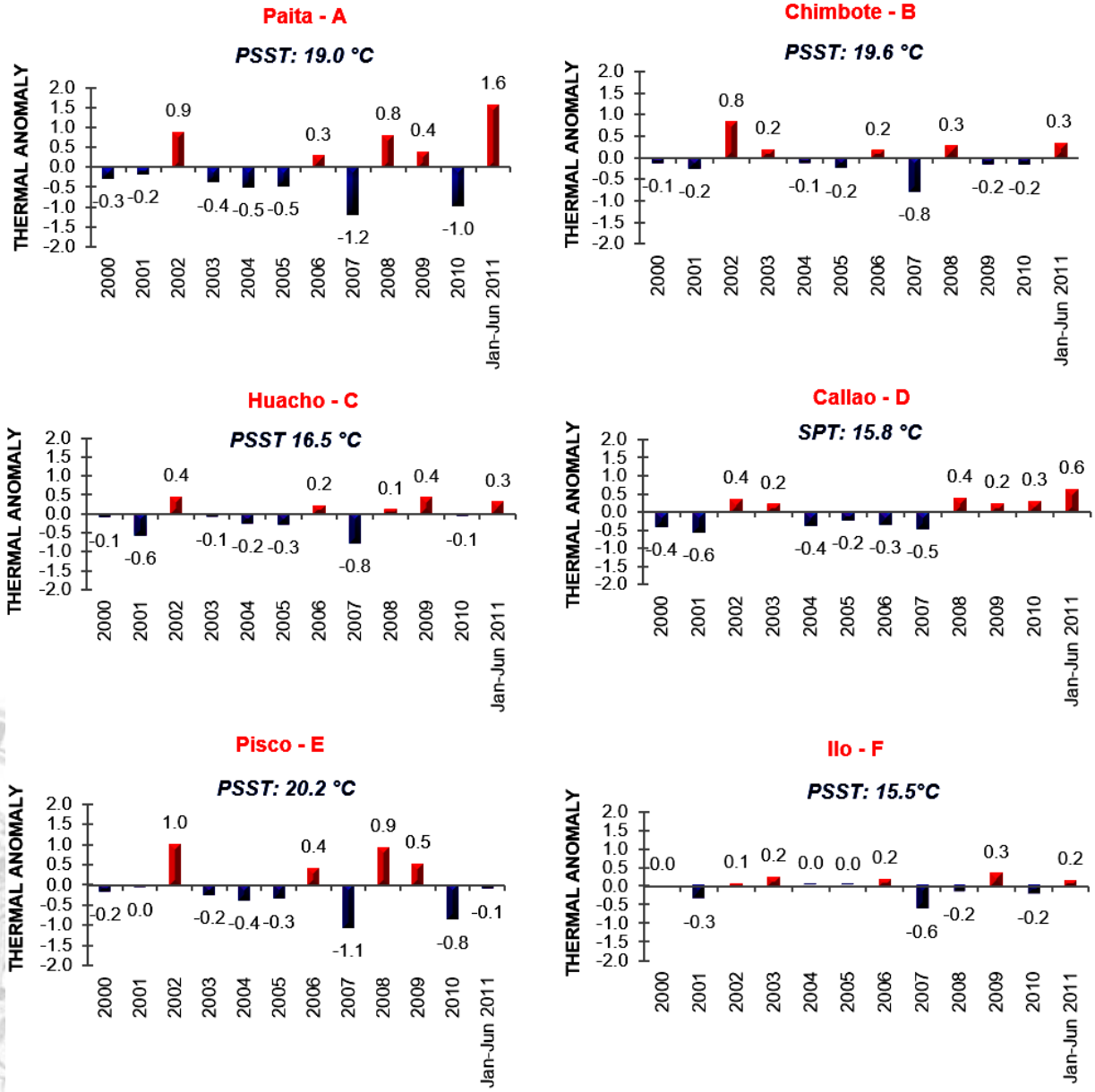

Figure 1. Variation of thermal anomalies in the following fishing ports: A) Paita, B) Chimbote, C) Huacho, D) Callao, E) Pisco, and F) Ilo. Positive and negative anomalies showed in red and blue. Those anomalies stand out above and below The Pattern of Sea Surface Temperature - PSST (0 ºC) showed on the graph.

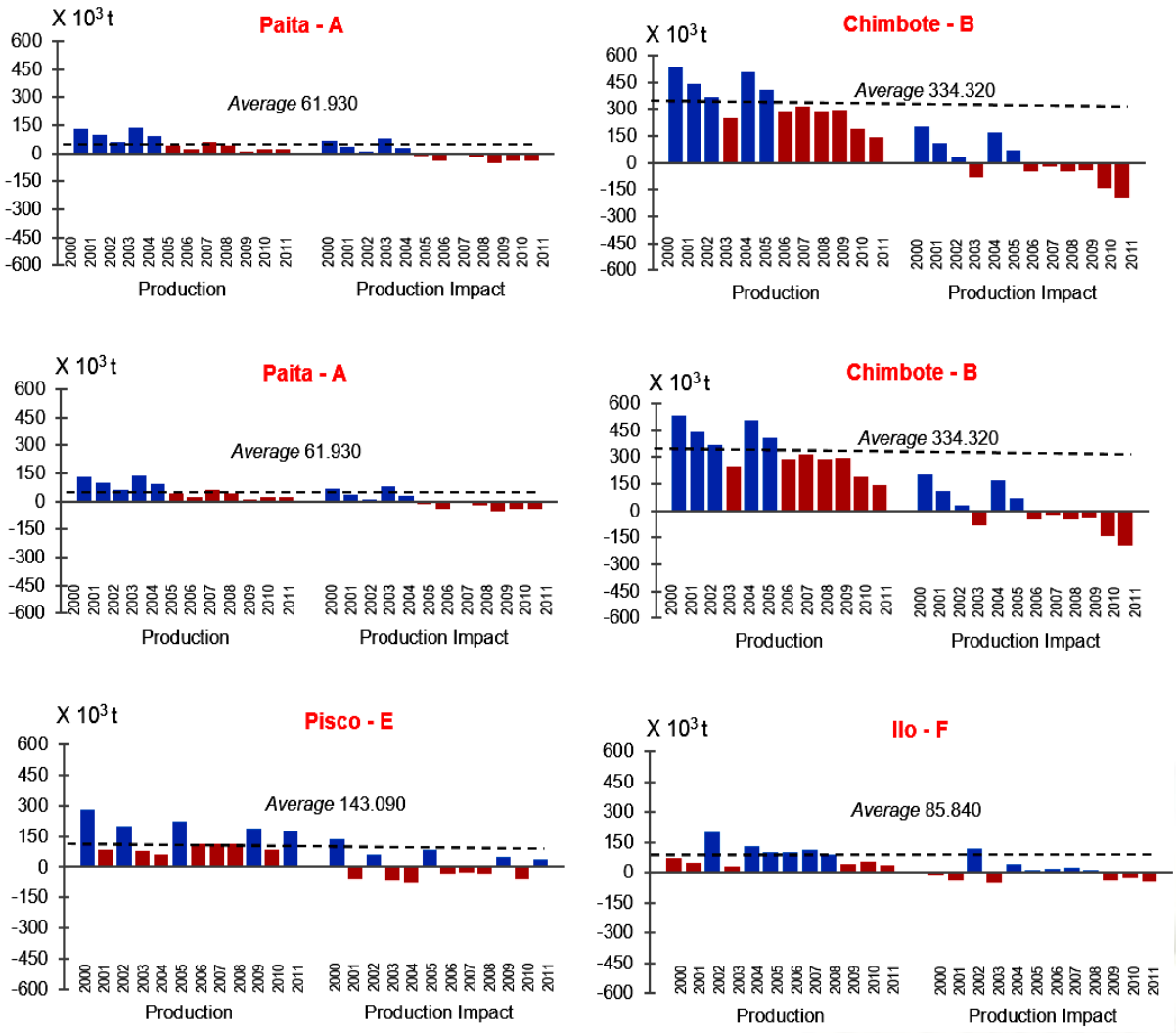

Figure 2. Variation of annual production volumes in thousands of tons and their impact on the Engraulis ringens "anchovy" sustainability through time for industrial fishing in the following ports: A) Paita, B) Chimbote, C) Huacho, D) Callao, E) Pisco, and F) Ilo.

Surveys applied to the heads of production in fishing companies stated that anchovy bioeconomy sustainability in Peru is directly influenced by the El Niño climate event and it is directly related to the social, economic and environmental sector.

Regarding anchovy sustainability projection up to 2050; 62.5% agreed it will be positive as consequence of better controls and regulations by the government. Regulatory measures such as individual catch quotas and closed seasons over anchovy have shown positive results. 25% of the interviewees agree that it depends on good governance, as long as long as regulations are followed. 12.5% believe that it will remain sustainable according to fishing statistics.

Due to the influence of climate change the fishing industry will be directly affected, this is why the government and partner institutions must develop emergency measures focusing on the state's marine economic resources. They should also request international aid to support the population in the event of a climate emergency (FAO, 2008). In addition, the ONU (2012) warns that if the industrialized countries as The United States, Japan, China, South Korea, Taiwan, and European countries continue to subsidize the fishing exploitation from countries in Western Africa and Southern Pacific, from Peru, Chile up to The islands in Oceania, in 2050 and onwards millions of people will experience food shortages and job crisis because of fish species depletion.

Due to the environmental impact of the El Niño Event in the marine ecosystem, the fishing industry becomes vulnerable. Climate change threatens extractive activities, therefore, it is necessary learned specialists who can contribute with preventive and action plans to reduce depletion of hydrobiological resources as consequence of El niño Climate event.

4. Conclusions

The highest bioeconomy sustainability stood out in the fishing port of Chimbote with production volumes of 334.320 tons, which represented 44% of the production and a value of 232.770 x 10^6 million USD during El Niño events between 2000 and 2011.

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